Wireless Apparatus Interference Avoidance/Resolution Methods And Apparatuses

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of wireless communication. More specifically, the present invention relates to the problem of concurrent wireless communication with multiple communication partners of different wireless communication protocols.

2. Background Information

Advances in microprocessor and communication technology have led to the increase in popularity of wireless communication. Once confined to the privileged, wireless voice communication have become affordable and available to the masses. Today, various efforts are under way to apply wireless communication to replace attachment cables used for attaching peripheral devices, such as printers, scanners and the like, as well as networking cables used for connecting clients, servers and the like. A leading candidate to accomplish the former is commonly known to those skilled in the art as the Bluetooth technology or Bluetooth protocol. Examples of technology to accomplish the later include the different variants of the IEEE 802.11 Standard published by the Institute of Electrical and Electronic Engineers, 802.11 (Frequency Hopping, Direct Sequence), 802.11a, 802.11b, as well as Home RF, also known as Shared Wireless Access Protocol (SWAP) to those skilled in the art.

It is desirable for various applications to have wireless devices that operate in accordance with different protocols, and overlapping frequencies, to operate

proximately located to each other. Most wireless protocols employ carrier sense collision detection, and random back off to resolve collision or interference. However, experience has shown that prior art collision detection and back off approaches could substantially degrade the performance of both networks operating with overlapping frequencies. Accordingly, an improved approach to allow wireless devices operating with different protocols and overlapping frequencies to operate proximately close to each other is needed.

SUMMARY OF THE INVENTION

A wireless device is provided with a wireless transceiver to transmit and receive signals in accordance with a first protocol to and from network devices of a first wireless network, and a controller manager to control operation of the wireless transceiver. The wireless device is further provided with a wireless receiver to receive signals transmitted in accordance with a second protocol by network devices of a second wireless network, and the controller manager is equipped to control operation of the wireless transceiver based at least in part on at least one signaling characteristic of the received signals from network devices of the second wireless network, to reduce interference with proximately located ones of the network devices of the second wireless network.

In various embodiments, the controller manager suspends operation of the wireless transceiver whenever interference is predicted. In other embodiments, the controller manager causes an appropriate filter to be applied whenever interference is predicted.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will be described by way of exemplary embodiments, but not limitations, illustrated in the accompanying drawings in which like references denote similar elements, and in which:

Figure 1 *illustrates an overview of an overlapping wireless network environment incorporated with the teaching of the present invention;*

Figures 2a-2c *illustrate a period of operation of the wireless devices of* ***Fig. 1****, in accordance with each of three embodiments;*

Figures 3a-3b *illustrate an architectural view and operation flow of "fully" enhanced wireless devices* ***104b*** *of* ***Fig. 1*** *in further detail, in accordance with one implementation;*

Figures 4a-4b *illustrate an architectural view and operation flow of "fully" enhanced wireless devices* ***104a*** *of* ***Fig. 1*** *in further detail, in accordance with one implementation;*

Figures 5a-5b *illustrate an architectural view and operation flow of "fully" enhanced wireless devices* ***104b*** *of* ***Fig. 1*** *in further detail, in accordance with another implementation;*

Figures 6a-6b *illustrate an architectural view and operation flow of "fully" enhanced wireless devices* ***104a*** *of* ***Fig. 1*** *in further detail, in accordance with another implementation; and*

Figure 7 *illustrates the concept of a notch filter.*

DETAILED DESCRIPTION OF THE INVENTION

In the following description, various aspects of the present invention will be described. However, it will be apparent to those skilled in the art that the present invention may be practiced with only some or all aspects of the present invention. For purposes of explanation, specific numbers, materials and configurations are set forth in order to provide a thorough understanding of the present invention. However, it will also be apparent to one skilled in the art that the present invention may be practiced without the specific details. In other instances, well known features are omitted or simplified in order not to obscure the present invention.

Parts of the description will be presented using software terminology commonly employed by those skilled in the art to convey the substance of their work to others skilled in the art. As well understood by those skilled in the art, these software quantities take the form of electrical, magnetic, or optical signals capable of being stored, transferred, combined, and otherwise manipulated through mechanical and electrical components of a digital system; and the term digital system includes general purpose as well as special purpose processors, systems, and the like, that are standalone, adjunct or embedded.

Various operations will be described as multiple discrete steps performed in turn in a manner that is most helpful in understanding the present invention, however, the order of description should not be construed as to imply that these operations are necessarily order dependent, in particular, the order the steps are presented. Furthermore, the phrase "in one embodiment" will be used repeatedly, however the phrase does not necessarily refer to the same embodiment, although it may.

*Referring now to **Figure 1**, wherein an overview of an overlapping network environment incorporated with the teachings of the present invention is shown. As illustrated, overlapping wireless network environment **100** includes wireless network devices **104a** of first wireless network **108a** operating in accordance with a first wireless protocol, and wireless network devices **104b** of second wireless network **108b** operating in accordance with a second wireless protocol. Wireless devices **104a** and **104b** are proximately located to each other, with at least some of wireless devices **104a** and **104b** being sufficiently close, such that when they transmit on the same frequency, they interfere (or "collide") with each other. In accordance with the present invention, one or more wireless devices **104a** and **104b** are incorporated with the teachings of the present invention, to facilitate pro-active interference avoidance or resolution. As a result, the amount of collision and the number of times wireless devices **104a** and **104b** have to go through the costly prior art back off, retry approaches are reduced, leading to overall improvement in efficiency for both wireless networks **108a-108b**.*

*In one embodiment, all devices **104a** are incorporated with the teachings of the present invention to predict when an interference will occur, and either pro-actively avoid or resolve the interference (hereinafter, "fully enhanced" devices). In another embodiment, only some of devices **104a** are so enhanced (one or more). In yet another embodiment, while only some of devices **104a** are so enhanced (one or more), other devices **104a** not so "enhanced" are nevertheless "minimally enhanced" to request the "fully enhanced" devices **104a** to at least preemptively notify them on when an interference is predicted to occur (hereinafter, "minimally enhanced" devices). The "fully enhanced" devices **104a** are further equipped to provide the preemptive notifications.*

*Likewise, in one embodiment, all devices **104b** are incorporated with the teachings of the present invention to predict when an interference will occur, and either pro-actively avoid or resolve interference (hereinafter, "fully enhanced" devices). In another embodiment, only some of devices **104b** are so enhanced. In yet another embodiment, while only some of devices **104b** are so enhanced, other devices **104b** not so enhanced are nevertheless "minimally" enhanced to request the "fully enhanced" devices **104b** to at least preemptively notify them on when interference is predicted to occur (hereinafter, "minimally enhanced" devices). The "fully enhanced" devices **104b** are further equipped to provide the preemptive notifications.*

*Referring now to **Figures 2a-2c**, wherein a period of operation for the wireless devices of **Fig. 1** in accordance with each of three alternate embodiments are shown. In each of these three alternate embodiments, first protocol of wireless devices **104a** of wireless network **108a** is assumed to be a frequency hopping protocol having a number of frequencies as shown, i.e. wireless devices **104a** hop from frequency to frequency in accordance with a pseudo random pattern to transmit signals. For ease of understanding, second protocol of wireless devices **104b** of network **108b** is assumed to be a constant frequency protocol (although in alternate embodiments, it may also be a frequency hopping protocol). In any event, to illustrate the present invention, at least one of the frequencies of the first protocol is the same frequency of the second protocol. Thus, if some of devices **104a** and **104b** are located sufficiently close to each other, and when one of devices **104a** selects the same frequency for transmission, interference (or collision) between these devices will occur, resulting in one or more transmission failures. For the illustrated example, frequency interference (or collision) is shown to occur at the 7th*

*and 14th hop (f_7 and f_{14}). That is, in accordance with the pseudo random pattern, in each of these two hops, devices **104a** transmit in the same frequency employed by devices **104b**. An example of a frequency hopping protocol is the Bluetooth protocol, and an example of a protocol having an interfering frequency with Bluetooth is the 802.11 protocol. [Note that the example interference at the 7th and 14th hop is not intended to suggest that the interference occurs at every 7th hop. The interference pattern is dictated by the intersection of the pseudo random pattern followed by the frequency hopping devices **104a** and the frequency employed by devices **104b**.]*

*In one embodiment, at least some of wireless devices **104a** and/or wireless devices **104b** are enhanced to proactively avoid interference (either "fully", or "minimally" as described earlier). The enhanced wireless devices **104a/104b** voluntarily let the other devices **104b/104a** be the "dominant" devices. That is, they voluntarily behave as the dominated devices. As the dominated devices, they voluntarily suspend operation (for a brief moment), whenever interference is predicted to occur, to pro-actively avoid interference with the dominant devices. As a result, the dominant devices may operate without being interfered with.*

*In another embodiment, at least some of wireless devices **104a** and/or wireless devices **104b** are enhanced to pro-actively resolve interference (either "fully" or "minimally" as described earlier). The enhanced wireless devices **104a/104b** apply appropriate corresponding filters, whenever interference is predicted to occur, to remove the corresponding interfering signals. As a result, interference is proactively resolved.*

Thus, in either of these embodiments, the time consuming collision detection, back off and retries (to resolve interference) are substantially reduced. Experience

has shown that the overall operating efficiencies of both networks improve, even in the case where one is a dominant network and the other is a dominated network.

Fig. 2a *illustrates a period of operation where only wireless devices* ***104b*** *(all or selected ones) are enhanced to be the voluntary dominated devices ("fully" or "minimally", as described earlier), allowing wireless devices* ***104a****, the frequency hopping devices, to be the dominant devices.* ***Fig. 2b*** *illustrates a period of operation where only wireless devices* ***104a*** *(all or selected ones) are enhanced to be the voluntary dominated devices ("fully" or "minimally", as described earlier), allowing wireless devices* ***104b*** *to be the dominant devices.* ***Fig. 2c*** *illustrates a period of operation where wireless devices* ***104a*** *and/or* ***104b*** *(all or selected ones) are enhanced to apply appropriate corresponding filters ("fully" or "minimally", as described earlier), whenever interference is predicted to occur, to remove the corresponding interfering signals. Thus, as illustrated, under* ***Fig. 2a****, enhanced ones of wireless devices* ***104b*** *will voluntarily suspend operation (for a brief moment) at example interference hops f_7, f_{14} and so forth, to pro-actively avoid interference. Whereas under* ***Fig. 2b****, enhanced ones of wireless devices* ***104a*** *will voluntarily suspend operation (for a brief moment), at example interference hops f_7, f_{14} and so forth, to pro-actively avoid interference. Under* ***Fig. 2c****, enhanced ones of wireless devices* ***104a/104b*** *will apply the appropriate corresponding filters (for a brief moment) at example interference hops f_7, f_{14} and so forth, to pro-actively resolve interference.*

Figures 3a-3b *illustrate the architecture and operational flow of an enhanced wireless device* ***104b*** *of* ***Fig. 1*** *for practicing the method of operation of* ***Fig. 2b****, in accordance with one embodiment (a "fully enhanced" embodiment). As described earlier, under the embodiment of* ***Fig. 2b****, wireless devices* ***104b*** *are enhanced to be*

*the voluntary dominated devices, allowing wireless devices **104a** to be the dominant devices, to proactively avoid interference. Enhanced wireless devices **104b** are to predict when an interference will occur, and at each of such predicted occurrence, voluntarily suspend operation (for a brief moment) to proactively refrain from interfering with wireless devices **104a**.*

*As illustrated in **Fig. 3a**, to enable wireless devices **104b** to so operate, each wireless device **104b**, in addition to conventional transceiver **1008** and controller manager **1006**, is additionally provided with state machine **1004**, receiver **1007** and interference avoidance manager **1005**. The elements are coupled to each other as shown.*

*Receiver **1007** is used to additionally receive signals transmitted in accordance with the first protocol between wireless devices **104a**, thus allowing the enhanced wireless device **104b**, to be able to receive signals in the first protocol, in addition to transmitting and receiving signals in the second protocol. Interference avoidance manager **1005** is equipped to determine at least a signaling characteristic of the first protocol, and predicts when an interference will occur, based on the determined one or more signal characteristics. For the illustrated embodiment, interference avoidance manager **1005** determines the pseudo random frequency hopping pattern followed by devices **104a**, and predicts when an interference will occur based on the determined pseudo random frequency hopping pattern. The determination may be made in any one of a number of techniques known in the art.*

*State machine **1004** is used to periodically generate a TX/RX or NOP control signal for controller manager **1006** to control transceiver **1008** accordingly, i.e. to transmit/receive or suspend operation (to pro-actively avoid interference). State machine **1004** generates the TX/RX or NOP control signal based on whether an interference is predicted by interference avoidance manager **1005**.*

*As illustrated in **Fig. 3b**, state machine **1004**, in addition to idle state **1010**, has two operating states (S1-S2) **1012-1014**. In state S1, state machine **1004** outputs the TX/RX control signal denoting performance of transmit/receive operation, and in state S2, state machine **1004** outputs the NOP control signal denoting suspension of transmit/receive operation.*

*Upon power-on or reset, state machine **1004** transitions from idle state **1010** to S1 state **1012**. While in S1 state **1012**, state machine **1004** remains in the state as long as an interference is not predicted by interference avoidance manager **1005**, outputting the TX/RX control signal for controller manager **1006**. Whenever an interference is predicted by interference avoidance manager **1005**, state machine **1004** transitions from S1 state **1012** to S2 state **1014**. While in S2 state **1014**, state machine **1004** remains in the state for a predetermined duration, outputting the NOP signal denoting suspension of transmit/receive operations for controller manager **1006**. The predetermined duration may be "hardwired", denoted through jumpers, or set through configuration registers, and the like. Upon expiration of the predetermined duration, state machine **1004** transitions from S2 state **1014** to S1 state **1012**. From S1 state **1012**, state machine **1004** continues operation as described earlier.*

*Except for the generation of the TX/RX and NOP control signals, and the control of transceiver **1008** by controller manager **1006** in accordance with these control signals, pro-actively avoiding interference with wireless device **104a**, each wireless device **104b**, including controller manager **1006** and transceiver **1008**, otherwise operates as known in the art.*

*Referring again to **Fig. 3a**, in one embodiment, in support of the "minimally enhanced" devices **104b**, interference avoidance manager **1005** further monitors*

*signals received by transceiver **1008** from other devices **104b**. In particular, interference avoidance manager **1005** monitors for requests from other "minimally enhanced" devices **104b** to be preemptively notified of a predicted occurrence of an interference. Upon receiving at least one such request, interference avoidance manager **1005** further causes each prediction to be broadcast for other devices **104b**, thereby allowing the "minimally enhanced" devices **104b** to be able to voluntarily behave as dominated devices (in favor of wireless devices **104a**, the dominant devices).*

*A "minimally enhanced" device **104b** may be constituted by slightly modifying controller manager **1006**, and additionally provided with only state machine **1007** (i.e., without providing receiver **1007** and interference manager **1005**). Controller manager **1006** is slightly modified to broadcast a request to the "fully enhanced" devices **104b**, to preemptively provide a prediction of interference, as described earlier. The broadcast e.g. may be made upon power on, reset, or periodically. State machine **1007** operates substantially as described earlier, i.e. outputting TX as long as no prediction of an interference occurrence is received, and outputting NOP for a predetermined duration whenever a prediction of an interference occurrence is received.*

***Figures 4a-4b** illustrate the architecture and operational flow of an enhanced wireless device **104a** of **Fig. 1** for practicing the method of operation of **Fig. 2a**, in accordance with one embodiment (a "fully enhanced" embodiment). As described earlier, under the embodiment of **Fig. 2a**, wireless devices **104a** are enhanced to be the voluntary dominated devices, allowing wireless devices **104b** to be the dominant devices, to proactively avoid interference. Enhanced wireless devices **104a** are to determine when a current frequency interferes with wireless device **104b**, and at*

*each of such determination (or "prediction", albeit with certainty), voluntarily suspend operation (for a brief moment) to proactively refrain from interfering with wireless devices **104b**.*

*As illustrated in **Fig. 4a**, to enable wireless devices **104a** to so operate, each wireless device **104a**, in addition to conventional transceiver **1108** and controller manager **1106**, is additionally provided with receiver **1107** and interference avoidance manager **1105**. The elements are coupled to each other as shown.*

*Receiver **1107** is used to additionally receive signals transmitted in accordance with the second protocol between wireless devices **104b**, thus allowing the enhanced wireless device **104a**, to be able to receive signals in the second protocol, in addition to transmitting and receiving signals in the first protocol. Interference avoidance manager **1105** is equipped to determine at least a signaling characteristic of the second protocol, monitor controller manager **1106**, determine if an interference is to occur based on the determined one or more signal characteristics, and proactively avoid the interference. For the illustrated embodiment, interference avoidance manager **1105** determines the signaling frequency of the second protocol, monitors the pseudo random frequency hopping pattern of controller manager **1106**, and determines if a current frequency is the same as the signaling frequency of the second protocol.*

*As illustrated in **Fig. 4b**, interference avoidance manager **1105** checks for interference, as controller manager **1106** controls transceiver **1108**, hopping from frequency to frequency, **1112**. If the current frequency is not the interfering frequency, interference avoidance manager **1105** allows controller manager **1106** to operate transceiver **1108** as known in the art, **1114**; otherwise, it causes controller manager **1106** to suspend transmit/receive operation, **1116**, pro-actively avoiding interference.*

*Except for the inclusion of receiver **1107** and interference avoidance manager **1105**, each wireless device **104a**, including controller manager **1106** and transceiver **1108**, otherwise operates as known in the art.*

*Referring again to **Fig. 4a**, in one embodiment, in support of the "minimally enhanced" devices **104a**, interference avoidance manager **1105** further monitors signals received by transceiver **1108** from other devices **104a**. In particular, interference avoidance manager **1105** monitors for requests from other "minimally enhanced" devices **104a** to be preemptively notified of a "predicted" occurrence of an interference. Upon receiving at least one such request, interference avoidance manager **1105** further causes each prediction to be broadcast for other devices **104a**, thereby allowing the "minimally enhanced" devices **104a** to be able to voluntarily behave as dominated devices (in favor of wireless devices **104b**, the dominant devices).*

*A "minimally enhanced" device **104a** may be constituted by slightly modifying controller manager **1106** (i.e., without providing receiver **1107** and interference manager **1105**). Controller manager **1106** is slightly modified to broadcast a request to "fully enhanced" devices **104a**, to preemptively provide a prediction of interference, as described earlier. The broadcast may be made e.g. at power on, reset or periodically. Otherwise, controller manager **1107** operates substantially as described earlier, i.e. operating transceiver **1108** to transmit and receive signals as long as no prediction of an interference occurrence is received, and suspending operation of transceiver **1108** for a predetermined duration whenever a prediction of an interference occurrence is received.*

Figures 5a-5b *illustrate the architecture and operational flow of an enhanced wireless device* ***104b*** *of* ***Fig. 1*** *for practicing the method of operation of* ***Fig. 2c****, in accordance with another embodiment (another "fully enhanced" embodiment). As described earlier, under the embodiment of* ***Fig. 2c****, wireless devices* ***104b*** *are enhanced to proactively resolve interference. Enhanced wireless devices* ***104b*** *are to predict when an interference will occur, and at each of such predicted occurrence, apply an appropriate filter (for a brief moment) to remove interfering signals of wireless devices* ***104a****.*

As illustrated in ***Fig. 5a****, to enable wireless devices* ***104b*** *to so operate, each wireless device* ***104b****, in addition to conventional transceiver* ***1208*** *and controller manager* ***1206****, is additionally provided with receiver* ***1207*** *and interference resolution manager* ***1205****. The elements are coupled to each other as shown.*

Receiver ***1207*** *is used to additionally receive signals transmitted in accordance with the first protocol between wireless devices* ***104a****, thus allowing the enhanced wireless devices* ***104b****, to be able to receive signals in the first protocol, in addition to transmitting and receiving signals in the second protocol. Interference resolution manager* ***1205*** *is equipped to determine at least a signaling characteristic of the first protocol, and predicts when an interference will occur, based on the determined one or more signal characteristics. For the illustrated embodiment, interference resolution manager* ***1205*** *determines the pseudo random frequency hopping pattern followed by devices* ***104a****, and predicts when an interference will occur based on the determined pseudo random frequency hopping pattern. The determination may be made in any one of a number of techniques known in the art. Additionally, interference resolution manager* ***1205*** *further determines an appropriate filter to be applied to remove the interfering signals of wireless devices* ***104a*** *at each predicted occurrence of interference. In one embodiment, the*

*appropriate filter is a notch filter, inversely formed based on the interfering signal (as illustrated in **Fig. 7**).*

*Thus, as illustrated in **Fig. 5b**, upon power on or reset, interference resolution manager **1205** monitors the transmit signals of devices **104a** to determine the pseudo random frequency hopping pattern followed by devices **104a**, and the appropriate filter to apply, **1210**. Thereafter, interference resolution manager **1205** determines if an interference is to occur, based on the determined pseudo random frequency hopping pattern, **1212**. Whenever an interference is predicted to occur, interference resolution manager **1205** outputs the appropriate control signal and filtering information for controller manager **1206** to apply the appropriate filter to proactively remove the interfering signals of wireless devices **104a**, **1214**.*

*Except for the determination of the pseudo random frequency hopping pattern of wireless devices **104a**, the determination of the appropriate filter, predicting when an interference will occur, and causing controller manager **1206** to apply the determined appropriate filter, each enhanced wireless device **104b**, including controller manager **1206** and transceiver **1208**, otherwise operates as known in the art.*

*Referring again to **Fig. 5a**, in one embodiment, in support of the "minimally enhanced" devices **104b**, interference resolution manager **1205** further monitors signals received by transceiver **1208** from other devices **104b**. In particular, interference resolution manager **1005** monitors for requests from other "minimally enhanced" devices **104b** to be preemptively notified of a predicted occurrence of an interference. Upon receiving at least one such request, interference resolution manager **1205** further causes each prediction to be broadcast for other devices*

***104b**, including the appropriate filter to apply, thereby allowing the "minimally enhanced" devices **104b** to be able to also proactively resolve interference.*

*A "minimally enhanced" device **104b** likewise may also be constituted by merely slightly modifying controller manager **1206**. Controller manager **1206** is slightly modified to broadcast a request to "fully enhanced" devices **104b**, to preemptively provide a prediction of interference, as described earlier. Again, the broadcast may be made e.g. at power on, reset, or periodically. Controller manager **1206** further causes the appropriate filter to be applied to received signals, whenever a prediction of an interference occurrence is received.*

***Figures 6a-6b** illustrate the architecture and operational flow of an enhanced wireless device **104a** of **Fig. 1** for practicing the method of operation of **Fig. 2c**, in accordance with another embodiment (another "fully enhanced" embodiment). As described earlier, under the embodiment of **Fig. 2c**, wireless devices **104a** are enhanced to proactively resolve interference. Enhanced wireless devices **104a** are to predict when an interference will occur, and at each of such predicted occurrence, apply an appropriate filter (for a brief moment) to remove interfering signals of wireless devices **104b**.*

*As illustrated in **Fig. 6a**, to enable wireless devices **104a** to so operate, each wireless device **104a**, in addition to conventional transceiver **1308** and controller manager **1306**, is additionally provided with receiver **1307** and interference resolution manager **1305**. The elements are coupled to each other as shown.*

*Receiver **1307** is used to additionally receive signals transmitted in accordance with the second protocol between wireless devices **104b**, thus allowing the enhanced wireless device **104a**, to be able to receive signals in the second*

*protocol, in addition to transmitting and receiving signals in the first protocol. Interference resolution manager **1305** is equipped to determine at least a signaling characteristic of the second protocol, determine if an interference is to occur based on the determined one or more signal characteristics, and proactively avoid the interference. For the illustrated embodiment, interference avoidance manager **1105** determines the signaling frequency of the second protocol. Additionally, interference resolution manager **1305** further determines an appropriate filter to be applied to remove the interfering signals of wireless devices **104b** at each predicted occurrence of interference. In one embodiment, the appropriate filter is also a notch filter, inversely formed based on the interfering signal (as illustrated in **Fig. 7**).*

*Thus, as illustrated in **Fig. 6b**, upon power on or reset, interference resolution manager **1305** monitors the transmit signals of devices **104b** to determine the signaling frequency of devices **104b**, and the appropriate filter to apply, **1310**. Thereafter, interference resolution manager **1305** monitors the pseudo random frequency hopping pattern of controller manager **1306**, and determines if the current frequency is the same as the signaling frequency of devices **104b**, **1312**. If the current frequency is not the interfering frequency, interference resolution manager **1305** allows controller manager **1306** to operate transceiver **1308** as known in the art, otherwise, interference resolution manager **1305** outputs the appropriate control signal, including the filtering information, to cause controller manager **1306** to apply the appropriate filter to the received signals, to proactively resolve interference, **1314**.*

*Except for the inclusion of receiver **1307** and interference resolution manager **1305**, each wireless device **104a**, including controller manager **1106** and transceiver **1108**, otherwise operates as known in the art.*

*Referring again to **Fig. 6a**, in one embodiment, in support of "minimally enhanced" devices **104a**, interference resolution manager **1305** further monitors signals received by transceiver **1308** from other devices **104a**. In particular, interference resolution manager **1305** monitors for requests from other "minimally enhanced" devices **104a** to be preemptively notified of a "predicted" occurrence of an interference. Upon receiving at least one such request, interference resolution manager **1305** further causes each prediction to be broadcast for other devices **104a**, thereby allowing the "minimally enhanced" devices **104a** to also proactively resolve interference.*

*A "minimally enhanced" device **104a** may likewise be constituted by merely slightly modifying controller manager **1306** (i.e., without providing receiver **1307** and interference manager **1305**). Controller manager **1306** is slightly modified to broadcast a request to "fully enhanced" device **104a**, to preemptively provide a prediction of interference and associated filtering information, as described earlier. Otherwise, controller manager **1307** operates substantially as described earlier, i.e. operating transceiver **1308** to transmit and receive signals as long as no prediction of an interference occurrence is received, and proactively filters received signals whenever a prediction of an interference occurrence is received.*

Thus, wireless devices equipped to proactively avoid interference have been described. While the present invention has been described in terms of the above illustrated embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. The present invention can be practiced with modification and alteration within the spirit and scope of the appended claims. *For example, in each of the "filtering" embodiments, the appropriate filtering may be "recursively" or "incrementally" determined. As a further example, each of enhanced*

*wireless devices **104a** and **104b** may be further enhanced to allow the pro-active interference avoidance/resolution function to be configurably enabled or disabled.* The description is thus to be regarded as illustrative instead of restrictive on the present invention.